TRANSMITTER AND DISTORTION COMPENSATION METHOD TO BE USED THEREFOR

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a transmitter and a distortion compensation method to be used therefor. More particularly, the invention relates to a distortion compensating method in a transmitter having a pre-distortion type linearizer.

Description of the Related Art

Conventionally, the transmitter of this type is constructed with a transmission signal generating portion 21, a pre-distortion type linearizer 22, a transmitter 23, a directional coupler 24, an antenna 25, a power calculator 26, a compensation value calculating means 27 and a demodulation means 28, as shown in Fig. 7.

Here, since a transmission signal is distorted due to non-linear characteristics or an amplifier or the like, in case of the transmitter 23 alone, the pre-distortion type linearizer 22 is provided between an output of the signal generating portion 21 and an input of the transmitter 23.

The pre-distortion type linearizer 22 performs correction for mutually canceling distortion component and correction data component generated in the transmitter 23. By

this, distortion of an output waveform of the transmitter 23 can be improved. The directional coupler 24 divides an RF signal. Most of the power thereof becomes an output of the antenna 25. However, a part of the power is input to the demodulating means 28. The power calculator 26 calculates an instantaneous power of a base band signal.

As a generation method of the compensation data input to the pre-distortion type linearizer 22, there is a method to return a part of the output of the transmitter 23 to the base band signal by the demodulator 28 and to arithmetically derive the distortion component from this signal and the result of the power calculator 26 by the compensation value calculating means.

In the distortion compensation method in the conventional transmitter set forth above, since the distortion component is arithmetically derived by returning a part of the transmitter to the base band signal by the demodulation means and calculating the distortion component from this signal and the result of the power calculator by the compensation value calculating means, a scale of the circuit becomes large to also increase current consumption.

SUMMARY OF THE INVENTION

The present invention has been worked out in view of the problem in the prior art set forth above. It is therefore an object of the present invention to provide a distortion

compensation circuit of a transmitter which can avoid increasing of a circuit size and current consumption.

According to the first aspect of the present invention, a transmitter assembly including a pre-distortion type linearizer correcting to mutually cancel a distortion component caused in a transmission signal and a correction data component, comprises:

first storage means for preliminarily storing the correction data.

According to the second aspect of the present invention, a distortion compensation method for a transmitter including a pre-distortion type linearizer correcting to mutually cancel a distortion component caused in a transmission signal and a correction data component, comprises steps of:

reading out a value corresponding to a transmission level from a first storage means preliminarily storing the correction data; and

inputting the read out value to the pre-distortion type linearizer.

The first storage means may manage correction data as table per transmission level. The transmitter assembly may further comprise second storage means having a plurality of table of the correction data per transmission frequency and environmental temperature and means for updating storage content of the first storage means with the corresponding table

of the second storage means when at least one of the transmission frequency and the environmental temperature is varied.

An address corresponding to the transmission level and a correction data corresponding to the address may be stored in the first storage means. The transmission level may be a sum of an alternating current voltage value corresponding to an instantaneous power of a transmission signal and a direct current voltage corresponding to a part of the power of transmission output signal. The correction data may be consisted of a predetermined amplitude value and a predetermined phase value of the transmission signal. The address corresponding to the transmission level and the correction data corresponding to the address may be stored in the first storage means.

Namely, the distortion compensation circuit for the transmitter assembly according to the present invention having the pre-distortion type linearizer stores the distortion compensation data to be transmitted to the distortion type linearizer in the first memory to sequentially update the data in the first memory with the corresponding table in the second memory depending upon variation of the transmission frequency and the environmental temperature . By this, the transmitter with good transmission waveform can be realized with restricting power consumption without causing increasing of circuit size.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood more fully from the detailed description given hereinafter and from the accompanying drawings of the preferred embodiment of the present invention, which, however, should not be taken to be limitative to the invention, but are for explanation and understanding only.

In the drawings:

Fig. 1 is a block diagram showing a construction of one embodiment of a transmitter according to the present invention;

Fig. 2 is an illustration showing a correspondence between V = (V1 + v2) and a generated address in an address generating portion of Fig. 1;

Fig. 3 is an illustration showing a correspondence between an address and a compensation data in a first memory;

Fig. 4 is an illustration showing a correspondence between a temperature and a frequency and a compensation table in a second memory of Fig. 1;

Fig. 5 is an illustration showing a gain and a phase characteristics of the transmitter alone of Fig. 1;

Fig. 6 is a flowchart showing a process operation of CPU of Fig. 1; and

Fig. 7 is a block diagram showing a construction of the conventional transmitter.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention will be discussed hereinafter in detail in terms of the preferred embodiment of the present invention with reference to the accompanying drawings. In the following description, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be obvious, however, to those skilled in the art that the present invention may be practiced without these specific details. In other instance, well-known structure are not shown in detail in order to avoid unnecessary obscurity of the present invention.

Fig. 1 is a block diagram showing a construction of one embodiment of a transmitter according to the present invention. In Fig. 1, one embodiment of a transmitter assembly according to the present invention is constructed with a transmission signal generating portion 1, a pre-distortion type linearizer 2, a transmitter 3, a directional coupler 4, an antenna 5, a power calculator 6, a first memory 7, a second memory 8, a CPU 9, an address generating portion 10 and a power detector portion 11.

The transmission signal generating portion 1 generates a base band signal of an I signal and a Q signal. The transmitter 3 modulates and amplifies the base band signal into an RF signal. Here, the transmission signal may cause distortion due to non-linear characteristics of the amplifier or so forth by the transmitter 3 alone. Therefore, the pre-distortion type

linearizer 2 is provided between an output of a the transmission signal generating portion 1 and an input of the transmitter 3.

The pre-distortion type linearizer 2 makes correction for canceling distortion component generated by the transmitter 3 and a correction data component by multiplying a correction data provided from the first memory 7 and the base band signal with each other. By this, an output waveform of the transmitter 3 is improved distortion.

The directional coupler 4 divides the RF signal. Most of the power divided by the directional coupler 4 becomes an output of the antenna, and a part thereof is input to the power detector portion 11. The power detector portion 11 detects the RF signal and outputs a transmission level to the address generating portion 10 as a direct current voltage value V1. The power calculator 6 calculates an instantaneous power of the base band signal to output to the address generating portion 10 as a certain alternating voltage value v2.

The address generating portion 10 determines an address of data to be output by the first memory 7 from the direct current voltage value V1 and the alternating current voltage value v2. The first memory 7 holds a compensation data in a form of a table for outputting the data contained in the designated address to the pre-distortion type linearizer 2.

A compensation data table of the first memory 7 is only

established under the same temperature and the same frequency for the transmitter 3. Therefore, it becomes necessary to update the compensation data table depending upon variation of an environmental temperature and a transmission frequency. In the second memory 8, the compensation data tables are stored for all cases with taking the transmission frequency and the environmental temperature. CPU 9 transfers the compensation data table from the second memory 8 to the first memory 7 depending upon variation of the environmental temperature and the transmission frequency.

Fig. 2 is an illustration showing a correspondence between V = (V1 + v2) and the generated address in the address generating portion 10 of Fig. 1. In Fig. 2, there is illustrated the compensation data table storing addresses with correspondence to the level of (V1 + v2).

In the shown compensation table, "0" is stored as an address to be output when the level of (V1 + v2) is "$< A0$", "1" is stored as an address to be output when the level of (V1 + v2) is "$A0 \leqq V < A1$", "2" is stored as an address to be output when the level of (V1 + v2) is "$A1 \leqq V < A2$", and "3" is stored as an address to be output when the level of (V1 + v2) is "$A2 \leqq V < A3$", ..., respectively.

Fig. 3 is an illustration showing a correspondence between the address and the compensation data in the first

memory 7 of Fig. 1. In Fig. 3, there is shown an example, in which the compensation data table #1 storing the address and the compensation data with correspondence is stored in the first memory 7.

In the compensation data table #1, a compensation data "$-\Delta G10$, $-\Delta\theta 10$" is stored in an address "0", a compensation data "$-\Delta G11$, $-\Delta\theta 11$" is stored in an address "1", a compensation data "$-\Delta G12$, $-\Delta\theta 12$" is stored in an address "2", a compensation data "$-\Delta G13$, $-\Delta\theta 13$" is stored in an address "3", ..., respectively.

Fig. 4 is an illustration showing a correspondence between the temperature and frequency and the compensation data table in the second memory 8 of Fig. 1. In Fig. 4, there is shown an example, in which the compensation data tables "table #0", "table #1", "table #2", "table #3" are respectively stored with correspondence with a temperature t ($<t0$, $t0 \leqq t < t1$, $t1 \leqq t < t2$, $t2 \leqq t < t3$ ...) and a frequency f (f0, f1, f2, ...).

Fig. 5 is an illustration showing a gain and a phase characteristics of the transmitter 3 alone of Fig. 1. Fig. 6 is a flowchart showing a process operation of CPU 9 of Fig. 1. Referring to Figs. 1 to 6, discussion will be given for operation of one embodiment of a distortion compensation circuit of the transmitter according to the present invention.

For example, considering the case that the transmission

frequency is fo and the temperature is t1 to t2, a content of the compensation data table #2 corresponding to this condition is stored in the first memory 7. The base band signal generated by the transmission signal generating portion 1 is modulated into the RF signal and amplified by the transmitter 3 via the pre-distortion type linearizer 2.

It is assumed that distortion of ΔG in amplitude of the transmission signal and $\Delta \theta$ in phase is caused in comparison with the ideal case where no internal distortion is present in the transmitter 3 (see Fig. 5). The RF signal output by the transmitter 3 is divided by the directional coupler 4 to input a part of the divided power to the power detector portion 11.

The power detector portion 11 detects this signal to output the result of detection to an address generating portion 10 as the direct current voltage value V1. The address generating portion 10 combines the direct current voltage value V1 and an instantaneous power value v2 derived by the power calculator 6 to determine an address of the data to be output by the first memory 7 from V1 + v2. In Fig. 2, assuming, for example, $A1 \leqq V1 + v2 < A2$, the address becomes "2". Therefore, in Fig. 3, the first memory 7 outputs data ($-\Delta G12$, $-\Delta \theta 12$) of the address "2" to the pre-distortion type linearizer 2.

Here, it is assumed that the temperature is varied from t2 to t3. In Fig. 4, CPU 9 transfers the content of the

compensation data table #3 corresponding to this condition from the second memory 8 to the first memory 7 to update the data content of the first memory 7. For example, data of the address "2" of the first memory 7 becomes ($-\Delta G22$, $-\Delta \theta 22$) taking the temperature characteristics of the transmitter 3 into account.

Namely, when the transmission frequency is varied (step S1 of Fig. 6) or when the environmental temperature is varied (step S2 of Fig. 6), CPU 9 updates storage content of the first memory 7 corresponding to variation content of the compensation data table in the second memory 8 (step S3 of Fig. 6).

Once updating of CPU 9 is completed, CPU 9 effects control for transmitting a value of the compensation data table in the first memory 7 corresponding to the address transmitted to the first memory 7 from the address generating portion 10 to the pre-distortion type linearizer 2 (step S4 of Fig. 6).

When the transmission frequency or the environmental temperature does not vary, CPU 9 effects control for transmitting a value of the compensation data table in the first memory 7 before updating corresponding to the address transmitted to the first memory 7 from the address generating portion 10 to the pre-distortion type linearizer 2 (step S4 of Fig. 6).

As set forth above, by storing the distortion correction data to be transmitted to the pre-distortion type linearizer in the first memory 7 and sequentially updating data in the

first memory 7 with the storage content of the second memory 8 depending upon variation of the transmission frequency and the environmental temperature, the transmitter assembly with good transmission waveform can be realized without causing increasing of circuit size and power consumption.

As set forth above, according to the present invention, in the transmitter assembly including the pre-distortion type linearizer which effects correction for mutually canceling the distortion component caused in the transmission signal and the correction data component, by inputting the value corresponding to the transmission level from the first memory means preliminarily storing the correction data to the pre-distortion type linearizer, current consumption can be restricted without causing increasing of circuit scale.

Although the present invention has been illustrated and described with respect to exemplary embodiment thereof, it should be understood by those skilled in the art that the foregoing and various other changes, omission and additions may be made therein and thereto, without departing from the spirit and scope of the present invention. Therefore, the present invention should not be understood as limited to the specific embodiment set out above but to include all possible embodiments which can be embodied within a scope encompassed and equivalent thereof with respect to the feature set out in the appended claims.